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Director's Office

November 21, 2008

Bob Bernstein Fermilab, MS 220

Prof. Jim Miller
Department of Physics
Boston University
590 Commonwealth Avenue
Boston MA 02215

Ron Ray Fermilab MS 220

Dear Bob, Jim, and Ron,

Thanks to all of you for your presentations at the recent Physics Advisory Committee (PAC) meeting, and to the Mu2e Collaboration for the proposal (P-973) for a muon-to-electron conversion experiment at Fermilab. The PAC was enthusiastic again about the possibility of reaching the sensitivity proposed. The PAC made the specific comments in the attached text.

The PAC noted the need for significantly more R&D in the near term to make a plan for, and to "demonstrate that four orders of magnitude improvement in sensitivity over previous experiments can indeed be achieved". While we are severely strapped for resources now, I invite you and your collaborators to work with the relevant Division and Section heads to find a way to get as much of this R&D done as we can. Clearly, it will help if you can expand the collaboration contribution as a very significant part of this R&D effort.

I do share the PAC's enthusiasm for your program, and as recommended, hereby grant Stage I approval to your proposal. I wish you good luck as we work together through the various stages of today's full approval process and beyond, as this difficult experiment is implemented and the results analyzed and published.

Sincerely,

Piermaria Oddone

J. Whitmore
J. Reidy
D. Levy
F. Bernthal
R. Tschirhart

Attachment

cc:		
Y. Kim	V. White	
P. Garbincius	G. Apollinari	
S. Holmes	C. Hogan	
R. Kephart	V. Shiltsev	
J. Appel	L. Bauerdick	
G. Bock	S. Dawson	
R. Dixon	M. Procario	

Excerpt from Physics Advisory Committee Comments and Recommenations, November 2008

P-973 Muon to Electron Conversion Experiment (Bernstein/Miller)

The Committee commends the Mu2e Collaboration for developing the proposal for searching for $\mu N \rightarrow eN$ conversion at the single event sensitivity level of 10^{-16} . The proposed level of sensitivity is four orders of magnitude below current limits, and has excellent potential for the discovery of new physics.

On September 26, in preparation for the Mu2e proposal, a Director's "pre-review" committee composed of 16 scientists and engineers was appointed to review the draft proposal. This day-long review, along with its preparatory work by a large committee, allowed for a detailed examination of the experiment and project. The input to the PAC via this report is highly appreciated. The review of the Mu2e concept was well executed, and the Committee endorses the recommendations of the report, which is available at

www.fnal.gov/directorate/program planning/directors reviews/Mu2eReview.pdf.

The Committee encourages the Mu2e proponents to review the report's specific recommendations and to respond in detail to each.

The P5 recommendation with respect to the Mu2e experiment states: "A muon-to-electron conversion experiment at Fermilab could provide an advance in experimental sensitivity of four orders of magnitude. The experiment could go forward in the next decade with a modest evolution of the Fermilab accelerator complex. Such an experiment could be the first step in a worldleading muon-decay program eventually driven by a next-generation high-intensity proton source. The panel recommends pursuing the muon-to-electron conversion experiment, subject to approval by . . . Fermilab. . . , under all budget scenarios considered by the panel." The Mu2e experiment outlined in the proposal to Fermilab is an appropriate response to the goals expressed above. However, it needs to be emphasized that this experiment is extremely challenging, and, as acknowledged by the collaboration spokespersons, a great deal of additional R&D work needs to be done to more solidly demonstrate that four orders of magnitude improvement in sensitivity over previous experiments can indeed be achieved. Of particular importance is the understanding and control of the backgrounds. They must be reduced and measured to unprecedented levels. The Committee notes that a 2005 HEPAP review of MECO stated that a minimal goal of achieving sensitivity significantly better than 10^{-15} was essential to justify the considerable effort and expense¹.

The proposal clearly relies a great deal on past work associated with the MECO project. The proposed production, transport, and detector solenoids have undergone multiple, detailed technical reviews, and this design work can be used as a firm starting basis. The Committee agrees that this critical-path area requires extensive, immediate effort to further develop. The proposed magnet R&D program, including the input from the review report, is appropriate. Other aspects of the R&D program also appear reasonable. The Committee recommends that consideration of demonstrating the required level of extinction, a key element in background suppression, be included in the R&D plan.

¹ From the 2005 HEPAP RSVP report: "A sensitivity of 10⁻¹⁵ is not an adequate level for MECO."

The Committee recommends that, in developing a more detailed technical plan, the collaboration improve the estimation of backgrounds and thoroughly identify the critical uncertainties in the background estimates. In the present document, no uncertainties on the background estimates were presented, and some conceivable background sources including neutrons and kaons were omitted. Thorough evaluations of upper limits for the various background sources are essential. The Committee recommends that wherever possible, measurements be performed to increase the reliability of background estimates, and that a "risk" analysis be developed to estimate worst case scenarios and possible remedies. Additional R&D expenses associated with improving the reliability of the background estimates should be included in the request to the Laboratory. In addition, since the goal is to make a definitive observation of $\mu N \rightarrow eN$ conversion, it will be essential to outline a strategy for unbiased experimental determination of the level of backgrounds that the eventual experiment experiences, and to develop a plan for blind analysis of the data.

The Committee also notes that the currently estimated cost of this challenging experiment, approximately \$180M (including substantial contingency), plus the cost of the additional R&D plan, is more than an order of magnitude greater than any previous search for lepton flavor violation.² It is of the utmost importance that the reliability of the proposal's estimates satisfies a commensurate level of scrutiny.

Impacts on the four Laboratory Divisions have been provided, and the Committee thanks the Divisions for supplying these estimates. The FTE estimates appear reasonable, although more support from the Computing Division for simulation infrastructure may be needed to help expanded collaboration effort execute the necessary detailed Monte Carlo studies.

The Committee is pleased that a number of strong groups have joined the Mu2e collaboration and encourages further growth in numbers of collaborators.

The Committee recommends that Stage I approval be granted to "P-973 – Proposal to Search for $\mu N \to e N$ with a Single Event Sensitivity Below 10^{-16} ", indicating that the experiment's scientific goals and concept for the experimental technique are worthy of serious consideration for development of a complete technical plan for subsequent approval stages following further R&D.

² The Committee was also informed that an additional expense of a few \$M are required for increasing the Booster rate from 10 to 15 Hz.